

<https://doi.org/10.48047/AFJBS.6.15.2024.15417-15426>



African Journal of Biological Sciences

Journal homepage: <http://www.afjbs.com>



Research Paper

Open Access

Comparative Study of Locking Miniplates vs. Conventional Miniplates in Mandibular Fracture Fixation: A Randomized Controlled Trial

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Volume 6, Issue 15, Dec 2024**Received: 2 June 2024****Accepted: 11 August 2024****Published: 03 Nov 2024**[doi:10.48047/AFJBS.6.15.2024.15417-15426](https://doi.org/10.48047/AFJBS.6.15.2024.15417-15426)

Introduction

Mandibular fractures represent a significant proportion of maxillofacial injuries, frequently resulting from trauma, road traffic accidents, and interpersonal violence. The primary objective in mandibular fracture management is to achieve stable fixation, promote uneventful healing, and restore occlusal function. Rigid internal fixation using miniplates has been the standard treatment approach; however, the choice between locking and conventional miniplates remains a subject of debate.¹⁻³

Locking miniplates incorporate a screw-to-plate locking mechanism that eliminates the need for intimate plate-to-bone contact, preserving periosteal blood supply and reducing the risk of screw loosening. In contrast, conventional miniplates rely on frictional stability, which may lead to hardware failure, delayed healing, and higher rates of infection. Recent studies suggest that locking systems provide better load distribution and improved stability under masticatory forces, leading to superior clinical outcomes.⁴⁻⁶

Abstract

Mandibular fractures are among the most common facial injuries requiring surgical intervention. The study aims to compare the efficacy of locking miniplates versus conventional miniplates in mandibular fracture fixation. A randomized controlled trial was conducted on 80 patients with mandibular fractures, divided into two groups: Group A (locking miniplates) and Group B (conventional miniplates). Clinical parameters, including stability, postoperative complications, and functional outcomes, were assessed over six months. Statistical analysis revealed a significantly lower incidence of postoperative infection, screw loosening, and malocclusion in the locking miniplate group ($p < 0.05$). Additionally, bone healing was significantly faster in Group A, as indicated by radiographic evidence at 8 and 12 weeks ($p < 0.01$). The results suggest that locking miniplates provide superior biomechanical stability and reduce hardware-related complications compared to conventional miniplates. This study highlights the advantages of locking miniplates in optimizing mandibular fracture management and provides evidence for their preference in clinical practice.

Keywords: Locking miniplates, mandibular fracture, rigid fixation, biomechanical stability, postoperative complications.

The advantages of locking miniplates include reduced stress at the bone-implant interface, improved screw retention, and lower incidence of plate fracture. However, the cost and technical expertise required for their application pose challenges in resource-limited settings. Comparisons between locking and conventional miniplates in mandibular fracture fixation have yielded inconsistent results, necessitating further high-quality randomized controlled trials to determine their efficacy.⁷⁻⁹

This study aims to evaluate the comparative effectiveness of locking versus conventional miniplates in terms of postoperative complications, fracture healing, functional outcomes, and biomechanical stability. By providing statistically significant results, this research aims to offer evidence-based recommendations for optimizing mandibular fracture management.¹⁰⁻¹¹

Methodology

A randomized controlled trial was conducted at Nishtar Institute of Dentistry Multan on 80 patients with mandibular fractures requiring surgical fixation. Patients were randomly assigned into two groups:

- **Group A (n=40):** Locking miniplates
- **Group B (n=40):** Conventional miniplates

Inclusion Criteria:

- Patients aged 18-60 years
- Unilateral or bilateral mandibular fractures requiring open reduction and internal fixation (ORIF)
- No underlying systemic diseases affecting bone healing

Exclusion Criteria:

- Pathological fractures
- Comminuted fractures requiring reconstruction plates
- History of osteomyelitis or previous mandibular surgery

Surgical Procedure:

All surgeries were performed under general anesthesia using standard ORIF techniques. The fracture site was exposed via intraoral or extraoral approaches based on fracture location. In Group A, locking miniplates were used with self-tapping screws, while in Group B, conventional miniplates with cortical screws were applied. Postoperative management included antibiotic prophylaxis, soft diet, and follow-up assessments at 2, 4, 8, and 12 weeks.

Sample Size Calculation:

Sample size was determined using Epi Info software with a confidence interval of 95% and power of 80%, considering an expected difference in complication rates of 20% between groups.

Outcome Measures:

- **Primary outcomes:** Stability, radiographic healing, occlusion restoration
- **Secondary outcomes:** Infection rate, hardware failure, pain scores (VAS), functional assessment (mandibular mobility)

Statistical analysis was performed using SPSS v26.0, with significance set at $p < 0.05$.

Results

Table 1: Patient Demographics

Variable	Group A (Locking)	Group B (Conventional)	p-value
Mean Age (years)	34.5 ± 7.3	35.2 ± 6.8	0.72
Male/Female Ratio	30/10	28/12	0.65
Fracture Site (Symphysis/Body/Angle)	12/15/13	10/16/14	0.88
Mean Surgery Duration (minutes)	72 ± 10	74 ± 12	0.57

There was no significant difference in baseline characteristics between the two groups.

Table 2: Clinical and Radiographic Outcomes

Outcome Measure	Group A (Locking)	Group B (Conventional)	p-value
Infection Rate (%)	5%	20%	0.02*
Screw Loosening (%)	2.5%	15%	0.01*
Malocclusion (%)	7.5%	22.5%	0.03*
Bone Healing at 8 Weeks (%)	85%	70%	0.04*
Bone Healing at 12 Weeks (%)	95%	82.5%	0.01*

Locking miniplates exhibited significantly lower complication rates and faster healing compared to conventional miniplates.

Discussion

The findings of this study demonstrate the superior clinical performance of locking miniplates over conventional miniplates in mandibular fracture fixation. The significantly lower incidence of postoperative infection and screw loosening in the locking group ($p < 0.05$) suggests that the locking mechanism provides greater biomechanical stability and reduces micro-movement at the fracture site.¹²⁻¹⁴

Radiographic evidence at 8 and 12 weeks postoperatively revealed faster bone healing in patients treated with locking miniplates, reinforcing their role in facilitating optimal osseous union. Previous studies have indicated that the absence of bone-plate compression in locking systems helps preserve periosteal circulation, thereby accelerating healing.¹⁵⁻¹⁷

The lower rates of malocclusion in the locking miniplate group further support their use in clinical practice. Conventional miniplates rely on direct bone contact for stability, which may contribute to micromotion and subsequent misalignment during functional loading. In contrast, locking systems provide a more rigid construct, reducing displacement and enhancing occlusal outcomes.

Despite these advantages, the cost of locking miniplates remains a limiting factor in widespread adoption, particularly in developing regions. Future research should focus on cost-effectiveness analysis and long-term evaluations of hardware survival rates.¹⁸⁻²¹ The results of this randomized controlled trial emphasize the advantages of locking miniplates over conventional miniplates in

mandibular fracture fixation. Locking miniplates demonstrated significantly superior outcomes in terms of infection rate, screw loosening, and bone healing. These findings align with existing literature suggesting that locking miniplates provide greater mechanical stability and reduced hardware failure due to their unique screw-to-plate locking mechanism, which eliminates the need for direct bone compression and preserves the periosteal blood supply.²²⁻²³

One of the most clinically relevant findings in this study was the significantly lower infection rate in the locking miniplate group (5% vs. 20%, $p=0.02$). Conventional miniplates rely on frictional stability, which requires rigid contact between the plate and underlying bone, potentially compromising vascularization and increasing the risk of infection²⁴. In contrast, locking miniplates function as internal fixators, preventing excessive stress at the bone-plate interface, thereby reducing bacterial colonization and subsequent infection²⁵

Overall, this study provides strong evidence in favor of locking miniplates as a superior alternative to conventional miniplates for mandibular fracture fixation. Their ability to enhance biomechanical stability, reduce infection rates, and accelerate bone healing supports their preference in modern maxillofacial trauma management.

The comparative analysis between locking miniplates and conventional miniplates in mandibular fracture fixation reveals notable distinctions in clinical outcomes, mechanical stability, and complication rates.

Mechanical Stability

Locking miniplates have demonstrated superior mechanical stability compared to conventional miniplates. The locking mechanism ensures a fixed-angle construct, reducing micro-movements at the fracture site and enhancing the overall rigidity of the fixation. This stability is crucial for promoting optimal bone healing and minimizing the risk of malocclusion.

Complication Rates

Studies have shown that the use of locking miniplates is associated with a lower incidence of postoperative complications, such as infection and hardware failure. The design of locking plates

allows for less disruption of the periosteal blood supply, which may contribute to a reduced risk of infection. Additionally, the enhanced stability provided by locking systems decreases the likelihood of hardware loosening or failure.

Clinical Outcomes

Patients treated with locking miniplates often experience improved clinical outcomes, including reduced postoperative pain and swelling, as well as a quicker return to normal function. The biomechanical advantages of locking systems facilitate early mobilization and functional rehabilitation, which are essential components of effective mandibular fracture management.

Cost Considerations

While locking miniplates may have a higher initial cost compared to conventional miniplates, the potential for reduced complication rates and improved patient outcomes can offset these costs over time. Fewer postoperative complications can lead to decreased healthcare utilization and associated costs, making locking systems a cost-effective option in the long term.

Technical Considerations

The application of locking miniplates requires precise surgical technique to ensure proper alignment and fixation. Surgeons must be adequately trained in the use of locking systems to maximize their benefits and minimize potential complications. However, the learning curve associated with locking plate systems is not significantly steeper than that for conventional systems.

Conclusion

Locking miniplates provide significant advantages over conventional miniplates in mandibular fracture fixation, including lower infection rates, reduced screw loosening, enhanced stability, and faster bone healing. Their biomechanical superiority makes them a preferable choice in clinical practice. However, cost considerations and accessibility must be addressed to facilitate widespread adoption. Further long-term studies are necessary to evaluate their efficacy in complex fracture patterns and different patient populations.

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